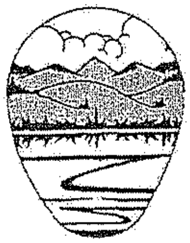


Burial — A Disposal Method for Dead Birds

The burial of dead birds in trenches, open pits, and landfills is rarely an acceptable method of dead bird disposal. In Arkansas and Alabama, no new in-ground burial pits are permitted — and states that do permit them consider this option the least desirable method or the method of last resort for mortality management. Until recently, however, burial was the only practical method some growers had to dispose of their dead birds — despite its potential for water pollution. Its use is now hedged with various guidelines and restrictions, such as construction requirements, loading rates, and setback distances from water resources, residences, and property lines. In all cases, the pits must be fabricated.

Pit Design and Fabrication

A fabricated burial pit is an open-bottomed, reinforced hole in the ground that has one or more openings at the top through which carcasses are dropped. An airtight cover above the openings prevents odors from escaping. The pit provides an environment in which aerobic and anaerobic microorganisms can consume most of the organic material. Only the feathers and bones should be left. Although disposal pits require minimal labor and supervision, they must be maintained in a sanitary, legal, and socially acceptable manner.

Fabricated pits should be made of concrete block, poured concrete, or treated timbers. Some prefabricated pits can be purchased from septic tank dealers and delivered to the farm ready for installation. Under no circumstances, however, should the pit be simply a hole in the ground dug with a backhoe and lined with tin. The decomposition process will produce very little water inside the pit, but the pit should be covered with soil and planted to vegetation to carry water away from the pit and to protect it from access by heavy equipment.

The openings — also called drop chutes — are made of plastic (PVC) pipes, which protrude out of the mound at intervals of five feet. The chutes should have tightly fitted but removable covers. The bottom of the pit is earthen with holes at intervals up the sides.

Location

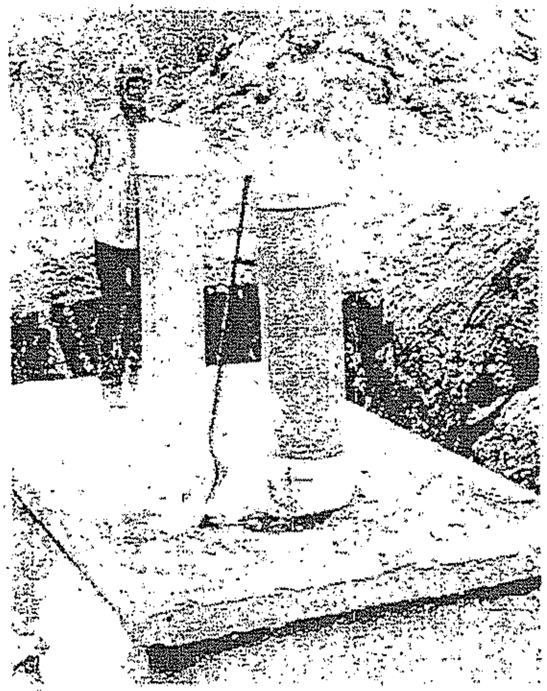
Location guidelines established by state agencies to protect water resources should be carefully observed. Generally, a disposal pit should be located at least 200 to 300 feet from dwellings and the nearest water well, 50 feet from property lines, 25 feet from the poultry house and 100 to 300 feet from any flowing stream or public body of water.

Before constructing a disposal pit, make certain that the soil composition is acceptable. Bedrock (especially limestone) and sandy soils should be avoided. Locate pits in soil where good surface runoff will occur. Sandy soils are not suitable for pit installations.

To prevent groundwater contamination, the pit's lowest point should be at least five feet above the highest known water table and at least five feet above bedrock to keep contamination from traveling along a rock fissure. To prevent water from seeping into the pit, construction on a slope, floodplain, or low-lying area should be avoided and in some states is not permitted.

Pit Size

The pit itself should be at least six feet deep with reinforced walls. Its size will depend on several factors, including the expected mortal-



Properly constructed disposal pits are made of concrete block, poured concrete, or treated timbers.

ity rate of the flock, bird size, and environmental conditions. Use the following table to estimate pit size:

TYPE OF MORTALITY	PIT SIZE IN CUBIC FEET PER 1,000 BIRDS
Broilers	50
Turkeys (to 18 weeks)	100
Layers (commercial)	55

For broiler mortalities, for example, if you have a 5 percent mortality rate in a flock of 20,000 and you raise five flocks per year, your burial pit should contain at least 250 cubic feet of disposal space. That is, it should be about six feet deep, six feet wide, and about seven feet long. Sometimes it can be more convenient to use several smaller pits to prevent overloading. In cooler climates, the pit size should be larger to accommodate a slower rate of decomposition. Keep in mind that some states may have maximum loading rates depending on the area's vulnerability to groundwater pollution.

Durability and Cost

The life of the pit will depend on its location and whether it is properly sized, constructed, and managed. To ensure total decomposition, the pit must be operated efficiently to protect the bacterial population. High acidity, for example, will retard the decomposition of dead birds. Disposal pits are most efficient during warmer months when bacterial action is greatest. Decomposition is slowed by winter temperatures or by accumulation of water in the pit. Grinding the carcasses or splitting open the dead birds (puncturing the abdominal cavity) will expel gases, increase the pit's efficiency, and extend its life.

The cost of constructing disposal pits varies widely depending on the materials used, site conditions, and the size of the pit. Geologic conditions — rocky soil, for example — can make digging expensive. As pit size increases, heavier construction is required for walls and tops; thus, higher costs are incurred. For a well-built pit, a useful life of five years is not uncommon, and some producers have reported that pits can be useful for eight to 10 years. Replacement is required when the pit is full.

Operation

After a pit is constructed, producers should check their facilities twice daily for mortalities and transfer them immediately to the pit. (Current law requires dead animals to be properly disposed of within 24 hours.) Covers on the drop chutes should be kept closed at all times to prevent odor and restrict access by children, animals, and rodents. Certain insects in a disposal pit are beneficial to the decomposition of the carcasses, but insects should not be allowed to develop into a nuisance. With proper handling the disposal pit costs nothing to maintain except for the labor of collecting the carcasses.

Drawbacks

Burial pits may attract flies and scavengers, and they may emit offensive odors. Further, today's farm may have insufficient land space for burial pits, or the capacity of the pits may be limited in winter. If the oxygen supply is insufficient, the decomposition process will be arrested. Slacked lime can be added to the burial pit to break down the tissue of the dead birds. It will also, in effect, sterilize the remains. If the site has poor soils or a high water table, groundwater pollution is a distinct possibility.

Before constructing or installing a prefabricated disposal pit, poultry producers should consult with their state's veterinary specialist, other agricultural offices, and environmental or natural resource agencies. These agencies may regulate the use of burial pits or disallow their use entirely, so seeking expert guidance before production begins often saves time and money. Local USDA Natural Resources Conservation Service or Cooperative Extension Service offices can provide technical assistance to growers who want to use disposal pits as part of their mortality management plans.

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INCINERATION — A DISPOSAL METHOD FOR DEAD BIRDS

Incineration, or cremation, is a safe method of carcass disposal and may be the method of choice in areas plagued by poor drainage and rocky soils. The major advantage of incineration is its ability to curtail disease. It is biologically secure, and it does not create water pollution problems. Even its by-product — ashes — is minimal, easy to dispose of, and unlikely to attract rodents or pests.

On the other hand, incinerators can be a costly item to install and operate and are expected to become more expensive as fuel costs rise. Further, while incineration destroys pathogens and poses no risk to water, its effect on air quality must be carefully monitored by poultry growers who choose this method of mortality management.

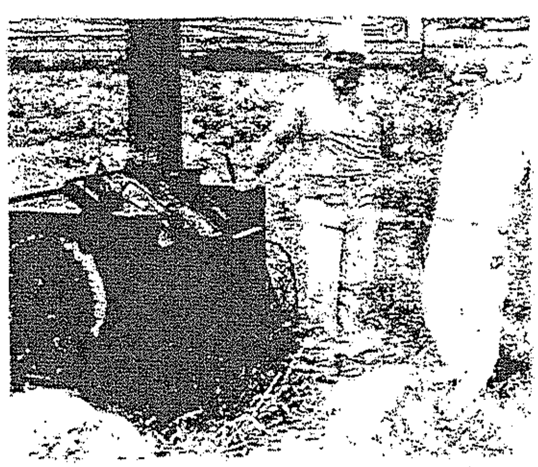
Incineration is not, then, a casual or inexpensive undertaking. Barrels or other homemade vessels are unsatisfactory burners and have serious consequences for the grower if they result in air pollution or unpleasant odors. Using incineration to manage poultry mortalities must be carefully planned: it must comply with dead animal regulations, meet all air quality standards, and justify investments in commercial equipment and the risk of increasing energy costs.

Notwithstanding these drawbacks, incineration is biologically the safest method of mortality management and simultaneously the method most likely to protect water resources. Producers considering this method of mortality management should consult with their state's agricultural, environmental, and veterinary medical agencies on the best way to incorporate this method. Agricultural incinerators do not generally require a permit, but they are designed to handle Type 4 wastes (e.g., animal remains, carcasses, organs, and solid tissue from farms and animal labs), but not other wastes (e.g., plastics and other organics).

Good Incinerator Design

A variety of commercial incinerators are available, and each one should be installed according to the manufacturer's specifications and local codes — typically outside, but under a roofed structure and away from any combustibles.

Incinerators should be sturdily built and able to accommodate daily mortalities. Indeed they should be sized to handle large loads and high temperatures; however, very large-scale loads, for example, loads running over 100 pounds per hour may require an operating permit. Growers should carefully estimate the capacity needed to manage daily mortalities and include other disposal methods in their resource management plans to cover situations in which heavy, unexpected losses can occur.



A variety of commercial incinerators are available.

An incinerator's material qualities are unlikely to become a problem if the unit is bought from a reputable dealer since stainless, aluminized, or heat-tempered steel is commonly used in their construction. Insulated models and those with heat shields may save energy and minimize the unit's exterior temperature. Those that have automatic controls will be more convenient and perhaps more economical.

Location and Operation

Incinerators should be used daily, so putting them in an area convenient to the poultry house will contribute to better management. Sheltering the incinerator from inclement weather will extend the life of the unit. For best results, it can be placed on a concrete slab.

To avoid nuisance complaints, locate the unit downwind of the poultry house, residences, and neighbors' residences. Finally, always check that the discharge stack is far enough away from trees or wooden structures to avoid fires, since incinerators burn at intensely high temperatures.

Incinerator Costs

Cost is no doubt the chief factor limiting the use of incineration in mortality management. The total investment includes the initial purchase, subsequent maintenance, and the interplay between the rate of burn and the price of fuel. Equipment costs vary depending on the size and type of the incinerator. Afterburner devices that recycle the fumes will help control odors and dust but will likely be priced as accessories. Expendable parts and grates will also need to be replaced periodically — perhaps every two or three years — and the whole system may need replacement (or overhaul) every five to seven years.

The rate of burn will vary depending on the weight, moisture, and fat content of the carcasses and on the loading capacity of the unit (e.g., incinerators may have to be loaded several times to handle a day's mortalities). Assuming an average burn rate of about 65 pounds per hour (based on past experience), and a fuel cost of $0.61 per gallon, a grower will expend $3.50 per day to incinerate 100 pounds of mortalities (1990 estimates). If fuel prices increase, so will the cost of each day's burn.

Growers have for the most part been unwilling to risk the high costs involved in this process, since they have no control over the price of fuel, and because the choice of incineration also means the loss of any nutrient value that the mortalities might have had if composted for land applications or rendered for other uses.

New technology may be the key to changing attitudes about incineration. Influenced by technological advances, current manufacturing specifications are producing a generation of incinerators that last longer, control emissions better, and burn more efficiently than older models in the field. Simply put: the new performance standards make it possible to separate the cost of incineration from the rising price of fuels. Thus, for example, trials on newer models have accomplished the same daily burn for less money than for older incinerators, even though fuel rates used in the computations were higher than those actually charged in 1990.

Incineration is an acceptable and safe method of poultry mortality management. It does not risk the spread of disease or water pollution. If, as now seems likely, technology succeeds in controlling its cost and its air emissions, incineration will become more competitive among the various methods available for managing this aspect of production. Growers considering incineration as a method of poultry mortality management are encouraged to plan this action in connection with their entire resource management system.

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Composting — A Disposal Method for Dead Birds

Composting poultry mortalities or dead birds is a relatively new, practical, and sanitary alternative to burial pits and incinerators. It is an economical, fairly odorless, and biologically sound practice for broiler, turkey, layer, and Cornish hen operations. Management commitment is the key to successful composting.

Composting resolves the disposal problem and yields a valuable product — a reduced odor, spongy, humus-like material that has several marketable uses ranging from soil conditioner to horticultural growing medium. Some states may require that composted birds be applied to the grower's own land; even so, composting has other values:

- Composting is environmentally sound; properly done, it decreases the potential for surface and groundwater contamination.
- Composting destroys disease-causing organisms and fly larvae.
- The materials needed for composting — mortalities, litter, and sometimes straw and water — are readily available.
- Once a composting system has been set up, it will not require much labor; and
- Compared to other options, composting is not a costly method of mortality disposal.

A Natural Process

Composting is a controlled, natural aerobic process in which heat, bacteria, and fungi fueled by carbon, nitrogen, oxygen, and moisture decompose organic waste, changing it into a stable product.

The grower's tasks are to collect the carcasses and place them in alternating layers with the manure and straw (or other carbon source); and to monitor the process to ensure that enough heat is being generated to complete the process of decomposition. The grower will also turn the composting mixture, usually by moving it from one bin into another. Turning the compost ensures that the entire mass is sufficiently aerated.

Composter Design and Operation

Composting poultry mortalities can be done in or outside the poultry house, but it should always be done in an environmentally safe and healthy manner, under a roof, and protected from rain, stormwater, or surface water flow. Most poultry mortalities will be composted in a facility housing a two-stage large bin composter. A typical two-stage large bin composter is designed as follows:

- The size of the primary bins is determined by the following equation:

V = flock size x (rate of mortality/total number of days) x average market weight x 2.5 cubic feet

  The secondary bins should be equal to, or larger, than the primary bins, since experience teaches that one cubic foot of primary bin and one cubic foot of secondary bin is needed per pound of daily mortality.

- The height of bins should not exceed 5 feet. Heights greater than 5 feet increase compaction and the potential for overheating.
- The width of the bins is usually selected to accommodate the loading equipment. A width of 8 to 10 feet is normal, but the bins could be wider.

- The depth of large bins is not restricted, assuming that the operator has appropriate mechanized equipment to manipulate the compost from front to back. Deeper bins are more difficult to enter and exit and take more time to work. Secondary bins can be larger, but they must have the same capacity as the primary bins (see Fig. 1).
- Extra primary bins will provide useful storage for litter and straw. If high mortalities occur, these bins could be used for composting.
- The ceiling height of the composter should be high enough to accommodate a front-end loader extended upward.

The decision to use a composting system for poultry mortality management means that the grower is committed to managing the composter facility properly and seeking help as needed. Once the composter bins have been adequately designed, the building itself should be considered. A few general principles apply to the composting facility.

- **Location and Access.** The composting facility should not be located near any residence. Offensive odors are possible during the composting process; and the handling of dead birds, manure, and litter on a daily basis may not be aesthetically pleasing. The site should be well drained and accessible; farm equipment is usually needed to carry dead birds and compost ingredients to the composter and to remove the finished compost.
- **Foundations.** An impervious, weight-bearing foundation or floor, preferably of concrete, should be provided under primary and secondary composting bins. Experience has shown that after frequent loading and unloading activities, dirt or gravel tends to become rutted and potholed. A good foundation ensures all-weather operation, helps secure against rodent and animal activity, and minimizes the potential for pollution of surrounding areas.
- **Building Materials and Design.** Pressure-treated lumber or other rot-resistant materials are necessary. A roofed composter ensures year-round, all-weather operation, helps control stormwater runoff, and preserves composting ingredients. Adequate roof height is also needed for clearance when using a front-end loader.

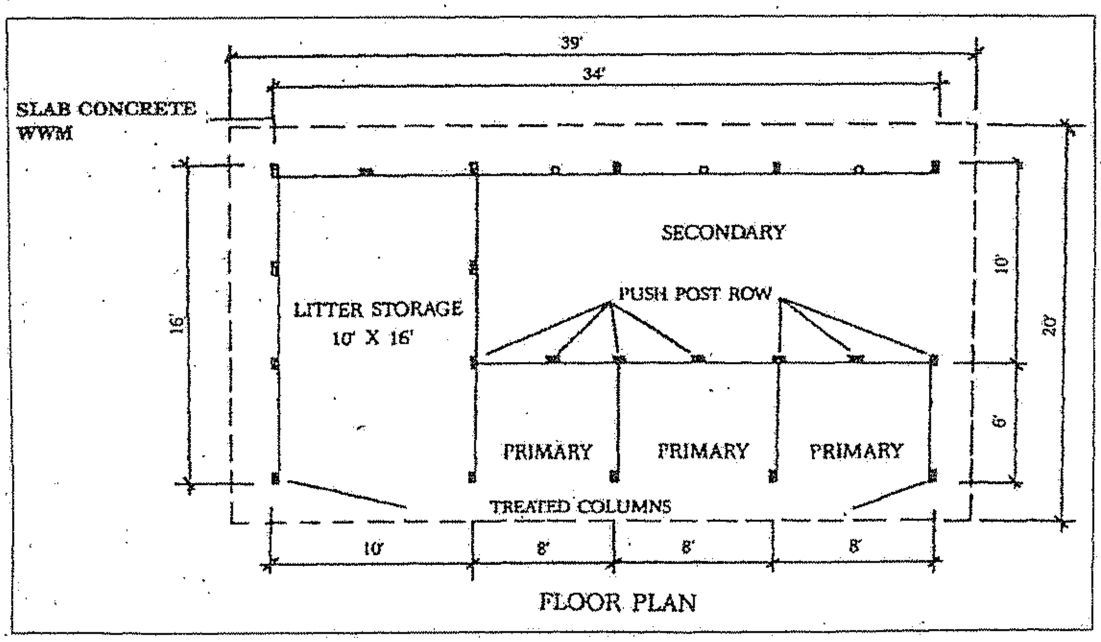

Figure 1.—Typical two-stage composter floor plan (not to scale).

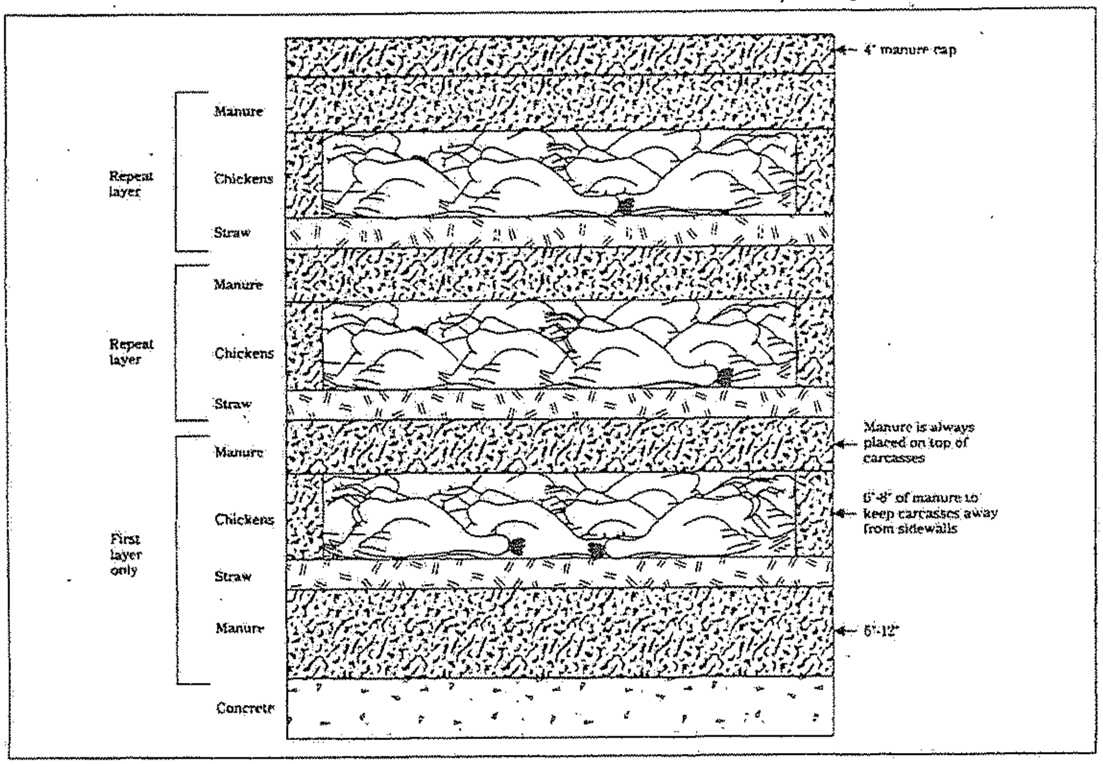

Figure 2.—Recommended layering for dead bird composting.

The amount of rain that is blown into the composter can be minimized by the addition of partial sidewalls or curtains and guttering along the roof.

Composting Recipe and Method

For composting poultry mortalities in a two-stage composter, a prescribed mixture of ingredients is used called a "recipe." The recipe calls for dead birds, litter, straw or other carbon source, and water (Table 1). Recipes for a single-stage composter differ slightly.

Proper layering of the recipe will ensure appropriate heat (from microbiological activity) for composting the mortalities in about 14 days. To begin, place 6 to 12 inches of litter or manure, followed by a 6-inch layer of loose straw to provide aeration, followed by a layer of dead birds. Depending on the moisture content of the manure or cake, water may or may not be added. Repeat this layering process until the pile or bin is full (see Fig. 2).

Table 1.—Typical recipe for composting dead birds with litter, straw, and water as ingredients.

INGREDIENTS	PARTS BY VOLUME
Dead Birds	1.0
Litter	1.5
Straw	0.5 – 0.75
Water	0.0 – 0.5

Water as an ingredient may not be necessary. Too much water can result in anaerobic conditions. An alternate recipe uses 1 part birds with 2 to 3 parts of litter cake (i.e., litter having a high moisture content).

Leave 6 to 8 inches of space between the edges of the dead bird layer and the wooden wall of the composter. This space allows air movement around the pile and keeps carcasses nearer to the center of the pile, where the heat is highest. Do not stack dead birds on top of each other. They may be adjacent to one another, even touching, but they must be arranged in a single layer. Spread litter or manure and straw as evenly as possible.

Use the same layering sequence (dead birds, litter, and straw) after loading mortalities that only partially complete a layer. If dead birds are carelessly loaded — stacked one on another or placed against the sidewalls of the structure — they will putrefy. Once the compost pile is complete, or full, "cap it off" with a 6-inch layer of dry litter, manure, straw, or similar material to reduce the potential for attracting flies and to provide a more pleasing appearance. This same recipe can be used for composting caged layers, broilers, turkeys, breeders, or other types of poultry.

Mixing, aerating, and moving the composting mass with a front-end loader or shovel will uniformly distribute the ingredients, add oxygen to the pile, and reinvigorate the composting process. Temperatures will rise after each mixing until most readily available organic material is consumed. After the pile is capped, wait 11 to 14 days before turning the mixture. However, if the temperature falls below 120 °F or rises above 180 °F, the compost pile should be aerated or mixed immediately.

Successful composting requires a specific range of particle sizes, moisture content, carbon-to-nitrogen ratio, and temperature. The following general rules apply:

- **Particle Size.** Particles that are too small will compact to such an extent that air movement into the pile is prevented. Material that is too large allows too much exchange of air, and so prevents the heat from building up properly. A proper mixture of size allows both air exchange and temperature buildup.

- **Moisture Content.** The ideal moisture content in the composting pile ranges from 40 percent to 60 percent. Too much moisture can cause the pile to become saturated, which excludes oxygen. The process then becomes anaerobic, a condition that results in offensive odors and attracts flies. Runoff from a composter that is too wet can pollute the soil or water. Too little moisture reduces microbial activity and decreases the rate of composting.

- **Carbon-to-Nitrogen Ratio.** Carbon and nitrogen are vital nutrients for the growth and reproduction of bacteria and fungi; therefore, the ratio of carbon to nitrogen (C:N) influences the rate at which the composting process proceeds. Conditions are most ideal for composting when the C:N ratio is between 15:1 and 35:1.

  If the C:N is too high, the process slows down because it has insufficient nitrogen. This imbalance can be corrected by adding more manure or litter to the compost pile. If the C:N ratio is too low, the bacteria and fungi cannot use all of the available nitrogen, and the excess nitrogen will be converted to ammonia, resulting in unpleasant odors. This problem is fixed by adding more straw or sawdust.

  More recent experience has shown, however, that composting poultry mortalities results in a partial compost. Hence, maintaining the exact carbon-to-nitrogen ratio, while important, is not critical. Many recipes now reduce or eliminate straw entirely, substituting cake, as previously noted, or even the composted product. In fact, 50 percent of the contents in the secondary bin can be input with a new batch of mortalities in the primary bin. This practice reduces the amount of compost that will need to be land applied by 50 percent.

- **Temperature.** The best indicator of proper biological activity in the composter is temperature. Use a probe-type 36-inch stainless steel thermometer, 0 to 250 °F, with a pointed tip to monitor temperatures within the compost pile. Optimum temperature range is 130 to 150 °F. When the temperature decreases, the general problem is that not enough oxygen is available for the bacteria and fungi. Oxygen can be replenished by turning or aerating the pile. Temperatures will rise as the composting process repeats itself.

  The cycle of composting, turning, composting can be repeated as long as there is organic material available to compost and the proper moisture content and C:N ratio are present. When temperatures reach the optimum range for three days, harmful microorganisms (pathogens) and fly larvae will be destroyed. Daily recording of the temperatures in the piles is important because it will indicate whether the bacteria and fungi are working properly.

Financial Considerations

Costs of composters depend on many factors — size, configuration (e.g., work areas, ingredients, and finished compost storage), and utilities. Some composting structures have been built for as little as $500; others, for as much as $50,000. No specific plan or layout for composters works best in all cases. Many different designs will perform adequately, but management capabilities determine the success of the composting process. Standard plans and management information for poultry mortality composters are available through local USDA Natural Resources Conservation Service or Cooperative Extension Service offices.

Financial aid or cost-share funding may be available to help pay for the design and construction of composting facilities. Check with your local conservation district, USDA Natural Resources Conservation Service, or Cooperative Extension Service offices to learn more about these programs.

Changes in the recipe and design of composters are an indication that this practice is still in development, and further refinements can be expected. In the meantime, the composter designs now available can be used not only to deal with routine mortalities, but also for catastrophic losses. Growers interested in using this mortality management approach are urged to contact the appropriate local, state, and federal agencies for assistance.

Composting Catastrophic Event Mortalities

Composting large numbers of poultry mortalities after a catastrophic event is relatively simple and inexpensive, and should be considered over burial for water quality protection. The process is the same as for normal mortality numbers, but without the bins.

Catastrophic mortality can be composted in the bedding or litter where the poultry were housed if the whole population is involved and adequate space and time are available, or they can be composted outside. Prior planning is necessary to ensure that the materials needed to build the composting pile or windrow (especially the bulking agent, sawdust, wood chips, or straw) will be on hand.

When composting catastrophic mortalities in a windrow, allow at least one cubic foot of bulking material per 10 pounds of expected mortality (e.g., 1,000 birds at three pounds each would require 300 cubic feet of bulking material); and size the windrow according to need. A window 12 feet by 6 feet high will hold approximately 300 pounds of mortality. Thus, 1,000 birds at 3 pounds each would require a windrow 3 feet long with appropriate end cover; and the materials needed per cubic foot of windrow length (300 pounds of mortality) would be 400 pounds of litter and 700 pounds of sawdust or other bulking agent.

Nine steps are needed to build a windrow:

- select a well-drained site;
- make a bed layer of wood chips 12 inches thick and 12 feet wide for the length of the windrow;
- add a 4-inch layer of fluffed straw as a base;
- deposit an 8 to 10 inch layer of mortalities, but stop about a foot from the edge of the lower layer;
- spray the mortalities with enough water to saturate the feathers;
- deposit a six-inch layer of sawdust or other bulking agent to the width of the birds; and
- repeat steps three to six as needed. Then,
- starting from the bottom, cover the entire pile with a layer of sawdust, two to four inches thick; and
- add to the length of the windrow as more mortality develops.

To maintain the windrow:

- use a long-stemmed thermometer to ensure that the temperature is rising — it should reach 135 to 145°F within a week —
- as the temperature declines (after 7 to 10 days) to 115 to 125°F, turn the windrow;

- in turning the material, be sure to lift and drop it in place (rather than merely pushing it) to form a new windrow;
- add water if the material is too dry (does not leave your hand moist when squeezed), or sawdust, if it is too moist (drips more than two drops in your hand); and
- cover any exposed carcass tissue in the new windrow with more sawdust.

After an additional three or four weeks the compost can be added to manure in storage for land application.

Because the poultry industry is so often concentrated in a geographic region, there can be many opportunities for recycling the by-products of production, including normal and catastrophic event mortalities. Composting normal and catastrophic poultry mortality on the farm can save transportation fees and tipping costs, reduce the potential spread of pathogenic diseases, and prevent groundwater pollution from burial practices.

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Mortality Composters — Small Bins, Minicomposters, and Packaged Deals

The composting process used in two-stage composting (see PMM / 4) can be adapted to fit various poultry operations and management styles. Mortalities are unavoidable whether the birds — or the operation — are large or small; but not all growers have the same access to mechanized equipment.

Small Bin Composting Systems

Small bin composters are two-stage composters developed for use on farms with limited equipment. Size of the primary bins is limited, primarily by the reach of the loader; so how many bins there will be is determined by how many are needed to dispose adequately of the mortalities. The secondary bins must be equal in capacity to the primary bins, but may be fewer in number than the primary bins and larger — they may be, and often are, twice the volume of the primary bins.

Recall the equation (in PMM / 4) for determining the size of the bins in the large bin composter:

V = flock size x (rate of mortality/total number of days) x average market weight x 2.5 cubic feet

The same equation can be used to size the small bins. Growers using limited equipment will probably want to build smaller bins. That is, they will build as many small bins — each about 5' x 5' x 8' — as they need to reach the required volume.

Table 1 illustrates this equation. It shows the number of primary bins that broiler growers will need depending on the size of their flock, the birds' weight and the volume in the bin for flocks ranging from 20,000 to 200,000 broilers.

Minicomposters

Growers raising fewer birds and wanting to use only hand labor may prefer another composting style. The advantage of using smaller minicomposters is that adequate decomposition of the birds can be completed in one cycle, so no secondary bins are required. These really small in-house composters, which can simply be pallets tied together to make a three-sided cubicle or box, do not even require floors. These bins can be constructed to approximate a 4' x 4' x4' cube. Litter from the previous flock is spread on the floor of the cubicle, then a single layer of birds are covered with twice that volume of litter (a two to one ratio). The composter should be capped off before a new bin is opened for the next flock. The compost can be land applied when the live birds are marketed. This composter can be placed either within the growout facility or outside the growout facility under a separate roofed building.

In-house composters can also be made using four screen-and-lumber panels (about 40' x 36') to construct a single square bin (Fig. 1). Each bin has a capacity of up to 30 pounds of dead birds per day or a total capacity of 600 pounds. Four to six such bins will handle the dead birds from a 20,000-bird broiler house at a cost of about $500. Position assembled bins at a location convenient for gathering the dead birds and for easy access for unloading between flocks.

Packaged Composters

Packaged or manufactured composters offer yet another way that poultry growers can improve on this ancient technique for handling organic waste. Growers who use prefabricated composters can collect the composted material

Table 1.—Number of First Stage Composter Bins Required for Broilers Using 5ft x 5ft x 8ft Bins.

NO. OF BROILERS	LBS. DEAD/DAY ON DAY 50* —lbs—	VOLUME IN 1st STAGE** —cf—	NO. OF BINS IN 1st STAGE
20,000	67	168	2
40,000	134	335	2
60,000	201	503	3
80,000	268	670	4
100,000	335	838	4
120,000	402	1,005	5
140,000	469	1,173	6
160,000	536	1,340	7
180,000	603	1,508	8
200,000	670	1,675	8

* Assumes mature weight of 4.2 lbs; flock loss of 4% or 0.8 bird/day/1000.
** (Total weight loss near maturity) x (2.5 cf/lb dead wgt) = volume storage required.

Source: USDA Composting Facility Guide.

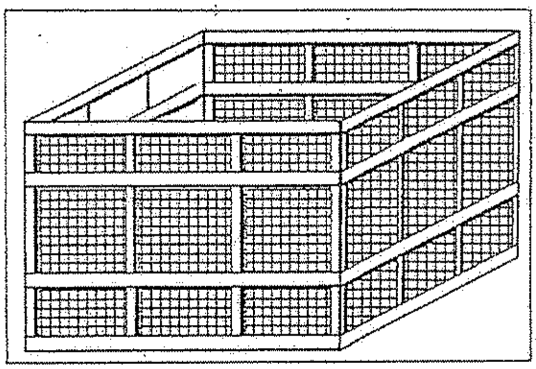

Figure 1.—Typical in-house composter.

that lies in the bottom of the box and shovel, or recycle, it back into the top. The compost, in effect, is substituted for the manure or litter used in the two-stage and minicomposters. Peanut hulls or other material can be added if a bulking agent is needed to supply oxygen, and a small amount of new litter can be added periodically to ensure the right carbon to nitrogen ratio. Recycling the compost, which can also be done in two-stage composters, has an additional environmental benefit: it can reduce by as much as 50 percent the amount of composted material to be land applied.

Prefabricated composters, which should be used according to the manufacturer's specifications, are primarily used by broiler growers producing up to 50 and 60 thousand birds. To reduce compaction and oxygen depletion, the loading rate per day should be reduced as the weight of the birds increase, and at maximum capacity, only two layers of birds should be placed in the composter each day — one layer is preferred.

Operating a Minicomposter

The process for composting in a single-stage, or minicomposter, begins with layering the recipe. The start-up materials are 200 pounds of litter, one-third bale of straw (though some find that straw is not necessary for effective composting), and 15 gallons of water. Add the ingredients to the bin in the following order: 6 inches of loose straw, 65 pounds dry litter, and 5 gallons of water. Repeat the layering process three times until all start-up ingredients have been used. Check the temperature by inserting a thermometer; when the material reaches 140 to 150 °F, the composter is ready to begin processing dead birds.

Form a V-shaped 18-inch deep trough in the center of the bin. Add straw, dead birds, litter, and water and cover or cap with start-up ingredients. Avoid placing dead birds closer than 6 inches to the walls. Mixing and aeration take place when the bin is prepared for the next load of dead birds (Fig. 2). Loading rates should not exceed 25 pounds per day per minicomposter. Record the temperature at a depth of 8 to 20 inches in the center of the pile daily. Repeat this procedure until the bin is filled. Thereafter, compost from prior operations can be used in place of new materials to restart.

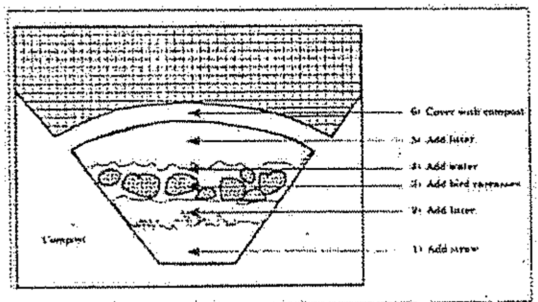

Figure 2.—Loading an in-house composter.

A minicomposter for outdoor use is usually 48" x 48" bin set on a 4-foot square is a workable size. Place the bins on a concrete pad under a roof to protect the compost from excessive moisture, anaerobic conditions, and pests. Outside composters use the same recipe and management as in-house minicomposters, but adjustments can be made to suit individual situations. The time and hand labor required to manage an outside composter must be carefully considered before installation. The cost of an outside minicomposter varies from $500 to $1,500, depending on the materials used.

Composting Compared to Other Disposal Practices

An emerging technology in the early 1990s, composting is now a preferred method of mortality management. It protects the environment and animal and human health, and it does not have quite the risk of air pollution that incineration does. In addition, composting can be scaled up or down in size, with corresponding differences in the grower's costs. Most comparisons between composting and other disposal methods use the price of the two stage composter as the base composter cost. In fact, minicomposters can be built for a third or less of that cost.

Changes in the recipe and design of composters are an indication that this practice is still in development, and further refinements can be expected. Growers interested in using this mortality management approach are urged to contact the appropriate local, state, and federal agencies for assistance. Standard plans and management information for poultry mortality composters are available through the USDA Natural Resources Conservation Service or Cooperative Extension Service offices.

Low interest loans or cost-share funding may be available in some states to help pay for the design and construction of composting facilities. Check with your state agencies and the USDA Consolidated Farm Service Agency to learn more about these programs.

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New Takes on the Rendering Process — Refrigeration, Fermentation, and Acid Preservation

Rendering — the process of separating animal fats, usually by cooking, to produce usable ingredients such as lard, protein, feed products, or nutrients — is one of the best ways to convert poultry carcasses into other products. We are now able to reclaim or recycle almost 100 percent of inedible raw poultry material, including bones and feathers, through rendering techniques.

Until recently, the animal protein in meat and bone meal residues was considered a waste of poultry processing; it was usually discarded, though it could sometimes be used as a fertilizer. Now rendering plants pick up or receive about 91 million pounds of waste annually to supply 85 percent of all fats and oils used in the United States. They also export 35 percent of the fats and oils used worldwide. Rendering operations provide a vital link between the feed industry and the poultry grower; they also help control odor and prevent air and water pollution.

Rendering has not been widely practiced, however, as an on-farm method of poultry mortality management. Few rendering facilities are located in the production area and carcasses do not remain fresh long enough to be delivered long distances. Further, any transportation of the carcasses off-farm could spread avian diseases.

The converse of these difficulties is, however, rendering's great advantage as a management technique, namely, it does remove mortalities from the farm and relieve the grower of environmental concerns related to other methods of disposal. Its potential economic benefit increases as more of the product is successfully recycled. Spurred by such considerations and concern to prevent further nutrient losses, growers and their industry partners are taking a second look at the rendering process.

Efforts to develop appropriate management and handling techniques to overcome obstacles associated with the routine pick up and delivery of carcasses to the rendering plant (especially the possible threat to avian health and the environment) have focused on long and short-term alternatives to the immediate delivery of carcasses for processing. The earliest management adaptations relied heavily on daily pickups and refrigeration; emerging technologies that may be safer and more cost effective include acid preservation, grinding and fermentation, and extrusion.

Preparing for Immediate Delivery

Raw or fresh poultry mortalities that are destined for a rendering plant must be held in a leak-proof, fly-proof container; and they must be delivered to, or be picked up by, a rendering company within 24 hours of death. All mortalities must be held in a form that retards decomposition until they are collected.

Refrigeration

Some producers are experimenting with a technique that combines on-farm freezing or refrigeration and the rendering process to determine whether freezing can be an effective way for growers to preserve the dead birds until they can be rendered. Large custom-built or ordinary commercial freezer boxes are being used to preserve dead birds until they can be picked up and delivered to the rendering plant. Custom-built boxes or units are usually free standing with self-contained refrigeration units designed to provide temperatures between 10 and 20 °F.

Ideally, these freezer units will have no environmental or health impacts. The smaller ones are designed to allow the immediate removal of the carcasses from the grower; the larger ones, to hold the birds frozen until the box is full or otherwise scheduled for delivery to the plant.

Large domestic freezers will hold about 250 to 300 pounds of dead birds. Specifically designed boxes can handle 1,600 to 2,000 pounds of dead birds and are easily loaded through various door arrangements. These units must also be sealed against weather and air leakage. Putting the birds in the freezer in a single layer and on a daily basis helps ensure that all the carcasses will be properly frozen. Fresh unfrozen carcasses are added to the top layer. Temperatures are set to freeze and should be regularly monitored to detect malfunctioning equipment, and overloading is strongly discouraged as that can also inhibit the freezing process.

The freezers remain on farm until the end of each growing cycle when they are emptied into a truck for transportation to the rendering facility. The refrigeration unit never leaves the farm, only the container holding the dead birds is removed or emptied.

Refrigeration is still an expensive option, though most of these units will last roughly 10 years and operate on energy efficient circuit boxes with an operating cost of about $1.50 per day. Transfer of pathogens or harmful microorganisms between farms has not been found to be a problem with this method of collection. Although additional experience is needed to determine the effectiveness of this option, its proponents stress its usefulness as a way to reduce or eliminate potential pollution and improve conditions on the farm.

Fermentation

Fermentation procedures, first proposed in 1984 and not commercially tested until 1992, are a more demanding but safer and perhaps more cost-effective method of preserving carcasses until the industry is prepared to handle their further processing and reuse. In fact, fermentation safely disposes of poultry mortalities by "processing" them on site. The pickled carcasses can be stored until the end of the growing cycle or until sufficient volume is attained for delivery to a rendering plant.

Fermentation begins in a grinder. The carcasses are ground into small particles (each piece measures roughly an inch) and a fermentable carbohydrate is added to the container. The grinding action disperses and mixes anaerobic lactic acid-forming bacteria found naturally in the birds' intestines; the carbohydrate provides the bacteria "opportunity" to ferment the ground mortalities; and the result is the production of volatile fatty acids and a reduction of pH — from 6.3 in the fresh tissue material to the 4.5 pH of the carbohydrate mixture.

It is the decline in pH that effectively preserves the birds' nutrient contents. In sum: the activity of anaerobic bacteria (*Lactobacillus*, sp., which are found naturally in poultry) converts the carbohydrate into lactic acid and lowers the pH to less than 5.0, thus inactivating the pathogenic microorganisms in the carcasses and preserving the organic materials.

The first commercial on-farm fermentation system was designed to accommodate daily broiler mortalities. It consisted of a grinder and tanks housed in a shed equipped with electricity and water. The grinder was constructed to incorporate the carbohydrate during the grinding process. The carbohydrate source may be sugar, whey, corn, or molasses, depending on which of these materials is most available to the grower. In the first commercial facility, corn was added on a 20-percent weight to weight basis.

The mixture of ground corn and mortalities passes from the grinder directly into an enclosed tank where the fermentation process takes place. Sugars in the corn are converted to lactic acid; the pH level drops; and within seven to 10 days, the lactic acid bacteria increase sufficiently to preserve the carcass nutrients. The fermented material can be kept in a stable state for several months, easily accommodating its transport at the end of a grow-out cycle.

The equipment should be cleaned routinely. After each use, the grinder can be flushed with a minimal amount of water that can be rinsed into the holding tank. The entire grinder should be disassembled and thoroughly cleaned each month.

The initial investment in this process is relatively high — for the building, grinder and tanks, and their installation. The first commercial system cost $8,200; the value placed on the fermented product was $.02 per pound. The net cost of fermenting the mortalities per pound was estimated at $.045 per pound, or fractionally less than composting ($.048) and almost half the cost of incineration ($.089, using 1992 figures).

Mortalities are a continuous and growing challenge for the poultry industry. The fermentation process is clearly a technology that meets the biological and environmental criteria required for the proper disposal of on-farm mortalities. Growers and their companies must carefully weigh these advantages against the managerial and economic trade-offs involved in selecting this practice.

Acid Preservation

Preserving foodstuff by acidification has been a widespread practice in agriculture. This method of preserving dead birds is the same as the fermentation process except that propionic, phosphoric, or sulfuric acid is added to the poultry carcasses, which are kept in an airtight, plastic container. Sulfuric acid may be preferred because it (1) retards spoilage, (2) excellently preserves the carcass, and (3) is relatively low in cost. However, safe handling and storage of the acids on-farm are important concerns.

Carcasses can be punctured with a blunt metal rod rather than placed through a grinder. Punctured carcasses can be separated from the acid solution without the accumulation of sludge in the holding container.

Selecting a Holding Method

The product resulting from acid preservation and lactic acid fermentation reduces the transportation costs associated with rendering by 90 percent. What is more important, however, is that these processes eliminate the potential for transmitting pathogenic organisms into the rendered products or the environment.

In an expanding poultry industry, the production of manure and mortalities will only increase. Producers should contact the renderers in their area to determine which holding and transportation methods are acceptable, and they must increase their search for safe, cost-effective disposal and reuse methods. Every possible safe method should be explored until each grower determines the method most compatible with his or her situation and management abilities. Rendering, like composting, adds value to the end product that can help offset mortality management costs.

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Developing Alternative Markets for Poultry Mortalities

Marketing considerations are often the deciding factor when egg producers and other poultry growers begin to design a mortality management practice for their operations. Chickens, like other animal species, have determined life cycles, foreshortened admittedly, for human consumption, but all chickens return eventually as elements to the earth from which they came. How we handle their "remains," especially when large quantities are involved, is at least partly related to whether they can be recycled, traded, or sold for additional use.

Would further processing of spent hens and other farm mortalities yield additional products or value-added components of products? Many growers, other agricultural groups, and market analysts believe they do.

If no markets exist, assuming for discussion, that all other considerations are equal, then traditional methods (e.g., composting and incineration) may be the best management practices to facilitate the decomposition process. Such practices are, when appropriately designed and operated, effective and safe, although stringently regulated.

Where markets for the processed by-products do exist, for example, at feed mills, then newer practices (e.g., refrigeration, fermentation, and eventual rendering) are perhaps the most efficient methods for disposing of spent hens and other farm mortalities. Rendering is costly, however, and usually feasible only at capacities that usually exceed the grower's or processor's normal production cycle. Alternative technologies can provide ways for growers and their companies to deal with these materials without having to send them (usually at a negative cost) to distant renderers.

Fermentation and composting are discussed elsewhere in this handbook (see fact sheets numbered PMM/4 and 5, and PMM/6). Other methods currently being developed by commercial manufacturers, agricultural research programs, and processors include new grinder/mixers to enhance the fermentation process, and dry extrusion systems.

Feather Removal

Feathers on carcasses are a problem for renderers. The feathers, which constitute about 10 percent of the body on a dry weight basis, are nondigestible to nonruminant animals and dilute the nutrient concentration of hen poultry meal. Feathers also absorb cooking fat, which makes the cooked product difficult to handle. Removal of the feathers by hydrolysis, that is by cooking the fowl at high temperatures, pressure, and humidity, also degrades the quality of the other proteins. If the spent hens could be plucked before the rendering process, then virtually any renderer could accept the product for processing. Thus, a variety of methods are being tried to determine whether picking the birds can be successfully performed at the renderers.

Experiments to date suggest that carcass feathers can be successfully picked up to 24 hours post-mortem, using a batch scalding and picking system. Scalding bath time and temperature must be carefully monitored and calibrated to the carcass temperature to prevent overscalding from fixing the feathers in their follicles. It also appears that the amount of time a bird is taken off feed does not make the process any more or less difficult, and the feathers remaining on the carcass constitute about 0.1 to 0.2 percent of the total picked body mass. If, therefore, renderers determine to install a simple, feather picking facility, they will be able to process unlimited numbers of spent hens without compromising their product's quality or their production schedules.

Another promising line of feather research suggests that a feather-degrading bacterium and its enzyme keratinase will soon make it possible to convert feathers into a digestible feed protein. If ground feathers can be converted into amino acids and peptides, poultry mortalities in general would have greater markets, since the feathers, at present detract from the marketability of the carcass. Feathers, like human and animal hair are made of a keratin protein that is resistant to digestion. About one million tons of feathers (and another million tons of animal and human hair) are produced each year. The keatinase must be purified from the feather degrading strain of *Bacillus licheniformis*, and then used in a bioreactor. This process is still being tested.

A Note on Grinders

The new grinders are basically automated, portable machines that can be used to grind up the mortalities — depending on the model, the machine can be used for broilers, large poultry carcasses (i.e., turkeys) and even hogs. The material is then transferred to a fermentation storage tank and kept on-farm until ready for use. The flow rate depends in part on the size of the mortalities, the smaller models handle approximately 75 pounds per minute; the larger ones may have a flow rate as high as 300 pounds per minute. The complete system has a grinder, catalyst mixer and a material transfer pump (see PWM/6 for a description of the uses and benefits of this management practice).

Dry Extrusion

The dry extruder was developed in the 1960s to process soybeans and grains. In this process, friction is used to generate high temperatures and pressure in a very short time. High temperatures are reached in as few as 30 seconds, and pressure quickly builds to 40 atmospheres. Under pressure, the cells rupture, that is, their contents extrude (are forced out), which frees the moisture in them. The product can then be heat-dried to a minimum moisture of about 10 percent before the product is cooled and stored.

Thus, the birds are cooked, sterilized, and dehydrated almost immediately. Until recently, the high moisture content of poultry by-products prevented the completion of the dehydration process without serious loss of the product's nutrient value. But in the extrusion process, the poultry byproduct can be diluted with corn, wheat middlings, or soybean meal. The result is a partially dehydrated nutrient-rich mixture that is 50 to 60 percent poultry by-product and 40 to 50 percent a dry ingredient of choice.

The products are marketable, for example, as a feed component for layers or as a protein supplement for broilers. Universities report that the extruded product produces outstanding results when fed to other broiler chicks, layers, and turkeys. Analyses performed on various dry-extruded products, including whole spent hens, turkeys, and broilers at different ages and treated and untreated feathers, indicate that the nutritional value of these products is comparable to, or better, than corn/soybean meal diets.

Microbiological analyses also support extrusion as a safe complement to the rendering process. Before and after extrusion tests indicate that the high heat and pressure are sufficient to dispose completely of aerobic microorganisms even if they were present in the birds prior to processing. In one test, avian infectious disease agents, such as *Salmonella typhimurium*, *Coccidia*, turkey rotavirus, and others, were added to the poultry by-product before extrusion. After extrusion, tests for these organisms were negative, and the turkeys who were fed this product likewise showed no visible signs of disease lesions and no viruses in their intestinal tracts.

The Feasibility of Extrusion

The process of dry extrusion begins with finding a way to bring the product safely to the extrusion facility where it can be mixed with the dry ingredient of choice. Then the mixture is cooked in the extruder, moved to the thermal dryer, cooled and removed to a final storage bin. This method has been tested, developed and implemented as a complement to rendering. Commercial operations exist in the United States, Canada, Poland, and other countries.

Its feasibility depends on (1) the volume of the by-product available for processing and its value to the operation without further processing, if any; and on (2) how the finished product will be used, that is, what exact moisture content and nutritional value is suitable for the market for which you are preparing the final product. Answers to these questions make it possible to determine which dry ingredient should be added to the poultry byproduct and whether the cost of production can be justified.

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Humane Methods for Dealing with Spent Hens

Hens produce fewer eggs as they age and at times the eggs may not be marketable. The producer can temporarily reverse this decline or recover production for six or eight months through an induced molt. By the time hens are two years old, and veterans of two or three production cycles, they will have to be replaced. The productive life of as many as 130 million hens must be terminated each year in the United States. On a per farm basis, the figure may run from 50,000 to 125,000 hens (which is about 375,000 pounds); or it could potentially run to about three million hens in a large complex.

In former times, these surplus or spent hens were marketed to poultry processing plants for a few cents a pound. After all, such hens can be canned or cooked. If cooked and deboned, the broth can be used for soups; the meat, for salads, soups, and chicken pot pies. Now, however, the increasing size and concentration of the egg industry, changes in breeding patterns (to make both egg and meat production more efficient), and the increased availability of broiler breeder hens and broilers have reduced the market for spent hens.

Leghorn hens now have smaller bodies and less muscle tissue; and their bones are often brittle. Broiler breeder hens, on the other hand, are bred to grow rapidly and produce a large amount of meat, and they have minimal bone particle problems. Consequently, food processors find it less economical to buy the spent Leghorns, preferring the more tender broiler breeder hens with their higher meat tissue to bone ratio.

Difficulties in Rendering

As fewer local processors want spent Leghorn hens, alternative markets or other management strategies must be used. Properly processed spent hen carcasses can be a valuable ingredient in animal feed mixtures for ruminants, poultry, mink farms, aquaculture, and pets. Getting the birds to renderers for eventual use in the feed milling industry is an attractive option but several obstacles remain to be worked out. For example, egg production units are far more scattered than broiler units. The rendering industry, on the other hand, is geographically distant from most egg producers. Only three plants in the United States are equipped to take the whole bird — feathers and all.

In addition, lengthy transportation to the renderers is costly and involves at least a degree of biological risk. The replacement of spent hens is seasonal and the processed yield per bird is small. It is difficult to convince renderers, who may be thinking about a commitment to this source, that the supply of spent hens will justify their investment in facilities and product development. Egg producers faced with this new problem have resisted binding contracts. Many egg producers like to sell to traditional processors whenever they can, while depending on renderers only when conditions compel them to do so.

Finally, renderers expect the birds to be delivered ready for processing — that is, dead on arrival. Therefore, even if rendering is the most attractive disposal option, all things considered, the egg producer is still the one responsible for humane death and preservation of the carcass. If spent hens are to be disposed of on the farm, they must still be removed from the

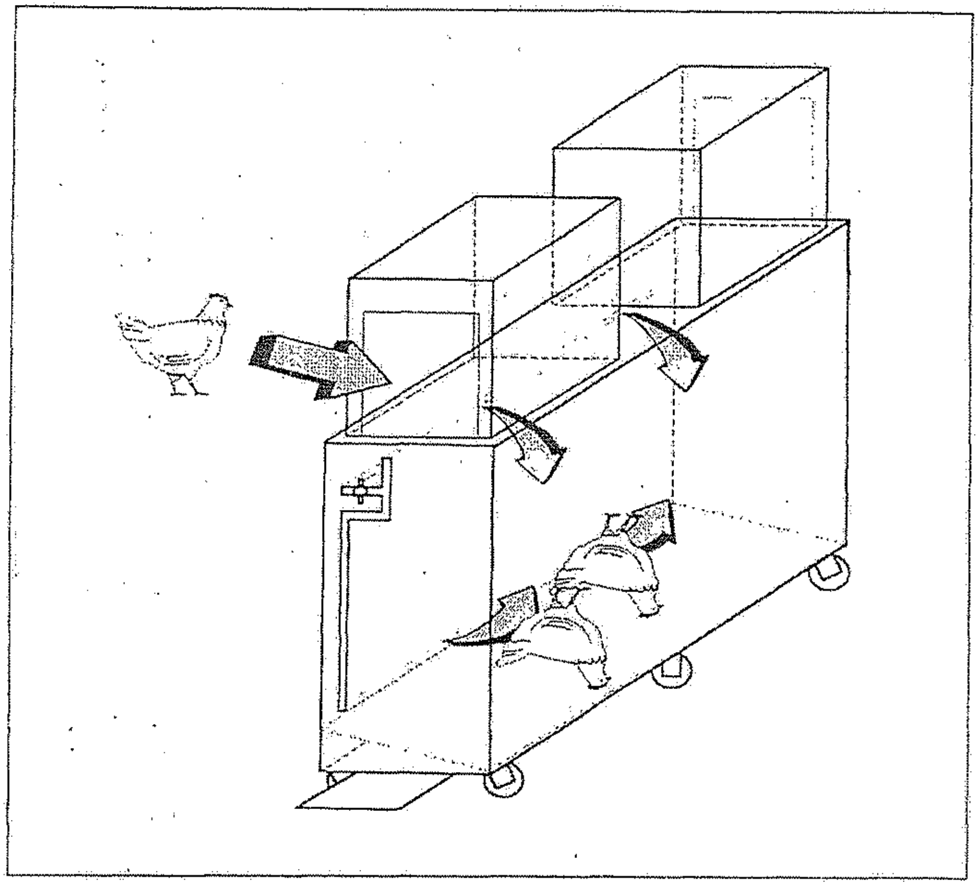

Figure 1.—Interior view of a modified atmosphere killing cart.

house and humanely killed. Then we must consider mortality management and whether the birds should be buried, incinerated, composted, rendered, frozen or fermented.

Humane On-farm Killing

Depopulating an entire layer house will be emotionally and physically taxing. Like all management practices, where and how it will take place must be properly planned. Planning criteria include concern for the animals' welfare, biological security, the environment, and the ability to perform the task efficiently and cost-effectively. The physical and emotional effect on farm personnel should also be considered. Guidance, standards, and regulations are available through local or state veterinary health and agriculture agencies. The American Veterinary Medical Association has specified cervical delocation as one way that spent hens may be humanely killed. However, recent studies in Britain indicate that this method may not induce immediate unconsciousness.

The method used in many commercial poultry processing plants may also be adapted for on-farm use. In this procedure, an electrical stunner is used in combination with a compact shackling line. An arm of the line near the end acts as a tipoff, automatically dropping the birds into a truck for removal from the farm. Alternatively, the birds could be delivered to a second on-farm station for scalding and defeathering the carcasses. Some drawbacks apply to this method, however. Care must be taken to ensure that each bird is properly stunned. Workers must be protected from dust and pathogens, depending on where the equipment is located; and the market for the spent hens must be strong enough to justify the investment in equipment, facilities, and training.

A third method of euthanizing the hens, which is being studied at the University of Georgia, is to modify or dilute their air supply with carbon dioxide (CO_2), nitrogen, or argon gas. These gases displace air in a container and the birds die of anoxia. Of the three gases, (CO_2) is preferred for this "modified atmosphere killing" (MAK) because it induces anoxia and respiratory arrest at higher levels of residual oxygen. Therefore, less extreme dilutions are effective. Carbon dioxide also anesthetizes the birds, making them less sensitive to pain. In on-farm trials of this technique, the induction of CO_2 rendered the chickens unconscious within 20 to 30 seconds and death followed within two minutes. The gas was effective at levels of 45 percent or more.

Using an MAK Unit

Producers can gain several advantages by using modified atmosphere killing to dispose of spent hens (Figure 1).

- The hens' death is guaranteed without undue suffering;
- The method is technologically simple, requiring minimal training;
- The equipment, a supply of CO_2 and a container, is easy to operate; and
- CO_2 is relatively inexpensive.

The unit must be carefully monitored to ensure that the ratio of CO_2 to air is sufficient to anesthetize the birds and shut down respiration. In the earliest trials, some of the birds in the unit were smothered. Others died as expected from anoxia, but extremely high levels of CO_2 were needed to effect this result; and some birds on the top layers (the last to be loaded) could not be dispatched by any amount of the gas, and had to be killed by cervical dislocation. Subsequent trials incorporated a number of improvements to prevent this outcome.

Reduced labor costs and ease of operation are important, but the premium that producers put on being able to quickly, efficiently, and humanely euthanize these hens is reflected in all management options.

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Site Selection for the Poultry Homestead

The design and placement of poultry facilities — and farmstead planning in general — are important elements in the subsequent operation and maintenance of an animal waste management system and the overall profitability of the poultry enterprise. The aesthetic value of the land and its attractiveness as a place to live are primary considerations; so, too, is knowing how to use the site wisely to control odor and dust and to protect the movement and quality of water (drainage and supply). Site selection is also an appropriate beginning for establishing a good neighbor policy. Activities during facilities construction may be subject to NPDES stormwater permitting if the total disturbed area on the farm exceeds 5 acres. Contact state agencies for specific requirements.

Housekeeping and Appearance

Properly located and well-maintained facilities will have minimal problems with odor, rats, flies, beetles, and mice. Placing the poultry house conveniently near the farm residence is useful; but the residence should remain attractive. The poultry house should be shielded (not visible) from the road, especially if it is near the setback distance to the property line; and grass and weeds should be controlled.

Carefully mowed grass and well-kept lawns will reduce reflected heat in the summer, and contribute to the site's attractiveness. Unmowed grass will harbor insects, rats, mice, and other vectors that increase flock losses. The area immediately surrounding the poultry house (50 feet at least) should be closely mowed. Low bushes and trees planted too near the poultry house will also harbor pests, and restrict air movement; if small trees remain in the area, the low-growing limbs should be pruned.

Building a vegetative windbreak or fence, on the other hand, will not only help the operation's appearance, it will also reduce dust and odors that might create a nuisance, or the perception of a nuisance, among your neighbors. If the house is sited within an adequate windshed, many potential air quality problems can be avoided with little on no adverse effect on neighbors and the community (see Fig. 1).

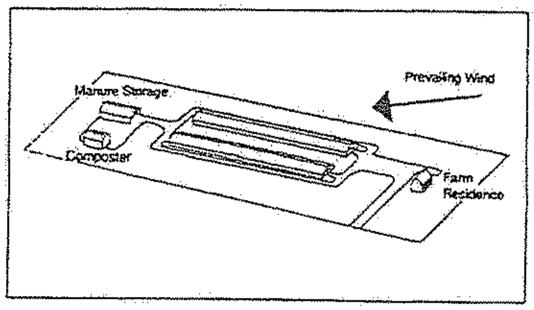

Figure 1.—Siting of a typical broiler operation.

Rainfall and Drainage

As few farmsteads are located on level ground, water drainage (both surface and subsurface) is an important consideration. Even a site on relatively high ground with adequate drainage, though it is less vulnerable to flooding, road wash outs, wet litter, and disease, may require supplemental measures to handle heavy rainfalls. Good drainage coupled with an appropriate use of gutters and grading around the outside of buildings will direct runoff away from the production facility and family home.

Water drainage helps ensure access to the facility at all times on all-weather roads. It also helps secure a safe drinking water supply. Using grassed outlet areas and buffer strips can help prevent runoff (and especially runoff that may have picked up waste materials from the houses, storage facilities, roads, or feed bins).

Subsurface drainage, including the natural flow of groundwater and agricultural drainage tiles, must be protected during construction and in all subsequent operations to prevent excessive nutrients or other possible contaminants from entering groundwater. Dry litter storage areas exposed to the weather should be covered and have an additional barrier, such as a plastic tarp, between the ground and the litter pad or gravel. If storage structures are used, they should be built on a concrete base.

Within the house itself, the removal of cake and wet litter should be part of production; waterers should be inspected for leaks; and other measures for mimimizing moisture, such as stirring, air drying, and ventilation, should be part of standard operating procedures. Foundation drains or footing drains can also be added to remove any subsurface water that might otherwise enter the house.

Maintenance Issues

Proper maintenance within the house is obviously important to lessen disease; reduce mortality, and help ensure production efficiency. Maintaining the exterior of the house is important to keeping up appearances. However, the exterior also contributes to maintaining healthful conditions in the interior of the house. Damage to siding, curtains, and roof can affect the temperature and humidity in the house, or allow for pest access. Food bins and equipment should be similarly checked and maintained in superior condition.

Litter Storage Sites

Litter storage sheds, stacks, or windrows should be convenient to the poultry house, but distant enough to reduce disease transmissions between flocks or houses. A distance of 100 feet is reasonable. Storage structures are usually 40 feet wide with a 14-to-16-foot clearance. The length varies depending on the amount of litter to be stored. Many storage sheds are three-sided — a rectangle with one end open. The interior wall should be strong enough to withstand the weight of piled litter and the force of front-end loaders.

Litter stockpiles or windrows should be properly prepared before litter is laid down. If the storage time exceeds one month, a pad must be available, and the stack or windrow should be covered to reduce flies and odor problems. Litter stored on the bare earth must be completely removed to avoid creating an area in which high salinity and nitrate-nitrogen can become a potential source of groundwater contamination.

Similar protective measures apply to the collection and disposal of poultry mortalities. Some traditional practices, especially open burial pits are no longer feasible and, in some places, are illegal. Alternative methods, such as incineration, composting, rendering, acid preservation, and fermentation can be used, but each of these requires appropriate structures and/or equipment.

The composting structure can be conveniently attached to the litter storage facility; the incinerator is more likely to be located in a separate, outdoor area. Refer to the appropriate fact sheets on litter storage and poultry mortality management for additional material on these topics.

Using Farm*A*Syst Tools to Make Improvements

Farmers who need practical help to identify which of their practices or structures may be a direct risk to the environment or who wish to gain access to new techniques for preventing pollution can participate in Farm*A*Syst, a voluntary program supported by the Cooperative State Research, Extension, and Education Service, the Natural Resources Conservation Service, and the U.S. Environmental Protection Agency.

Farm*A*Syst was specifically designed to help rural residents become knowledgeable about water pollution risks and to help them develop an action plan to correct potential problems. It is also a useful tool for site selection and general farmstead planning. Its materials include assessments of water well design and location, nutrient contamination, septic systems, pesticide and petroleum storage, household and farmstead hazardous waste and waste disposal, and other points of intersection between the facility and the environment.

OTHER ENVIRONMENTAL ISSUES

Conclusion

Proper siting and design of a poultry facility is important to the economy and success of the whole operation. It prevents problems before they arise, thus saving the grower money, time and worry, and best of all, it protects the environment and community from serious problems or distressing nuisances.

Poultry farms that are properly designed and maintained reduce the chance of complaints, protect farm workers, and build harmony in the community. Such farms assure citizens concerned with animal welfare that the poultry grower also cares enough for animals to give them a clean and comfortable environment. The grower who maintains an approachable farmstead shows the community that being neighborly is not a defensive measure, but a natural part of doing business.

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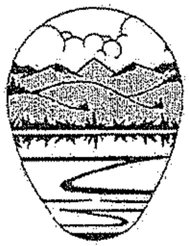

Using Regulations as Management Principles

Successful farmers have always been concerned about soil and water quality. Today more than ever, achieving this goal requires not only commitment but hard work.

It may be true that farmers, growers, and other producers would not usually call government regulations "helpful." However, the federal, state, and local regulations that apply to poultry and other livestock operations contain useful guidance for siting the facility and managing it properly.

Regulations can include zoning rules, requirements for construction permits, site inspections by certified engineers, and filing for public notice and approval before beginning or modifying livestock facilities, particularly for large units.

The U.S. Environmental Protection Agency defines a concentrated animal feeding operation (CAFO) as an operation that has more than 1,000 animal units (one animal is a 1,000 pound beef; and as applied to poultry, it is 100,000 broilers or laying hens, if there is a continuous overflow watering system; 55,000 turkeys; 30,000 laying hens or broilers, if a liquid manure system is used; or 5,000 ducks). Increasingly, however, states and counties are adding a variety of size and class distinctions to their regulations, based on local perceptions about the facility's potentially harmful effects on the environment.

Other regulations usually deemed "limiting," apply to the site once operating permits have been granted. These regulations may include

- restrictions on manure applications,
- separation and setback distances,
- recordkeeping,
- operating procedures for dry and liquid waste management facilities, and
- agreements establishing the conditions for transferring or decommissioning the facility.

But are these rules only limitations? Most environmental regulations are a response to the public's demand for clean water and its fear that growers are not sufficiently concerned about the risks inherent in livestock concentrations. Growers are not unaware of these risks, but they also know that if their sites are properly managed, the risks are far less than perceived. Looked at proactively, zoning and permit regulations can help growers break down the public's misconceptions and fear of modern animal agriculture.

Zoning can establish the right of poultry facilities to exist without resorting to public hearings for special use permits. Zoning also helps control urban sprawl; that is, it reduces the sudden appearance of highway businesses that often complain about farms that were established long before the highway was developed.

Separation and setback distances may also be beneficial. They ensure a large land area for manure utilization and management, thus helping with fly and odor problems and contributing to the farm's ultimate sustainability. Deep setbacks, however, encourage livestock concentration. Once a site is found that meets setback requirements, the incentive is to put as many animals as possible on that piece of property.

It is a given that as livestock facilities grow in size and concentration, so does the size of the waste stream and the number of environmental regulations. Growers will get the full benefit of the regulations' protections by participating in the rulemaking and by perceiving compliance, not as interference but as an opportunity to demonstrate their management skills to the community as well as to the regulating agencies.

Thus, for example, growers required to have a written manure management plan can use the planning process to get more control over when and how they manage this product — and the more control they have, the more likely they are to use manure as an asset rather than a liability. They will, in all likelihood, review conditions in the houses that may be affecting the quality of the manure, making storage difficult, and leading to complaints about odors and flies — and even, perhaps, to bad feelings about massive land applications. Once satisfactory storage arrangements have been made, land applications can be responsibly and timely planned to achieve crop nutrient requirements.

Using the Market to Replace Regulations

Environmental regulations, their benefits notwithstanding, also have some unintended consequences. For example, statutes based on approved practices limit the growers' incentive to innovate. The cost associated with compliance (and the criminalizing of environmental neglect) actually leads to larger facilities as growers attempt to bring down their per unit costs. Even more important from this standpoint, however, is the very foundation of environmental law: the "no discharge" rule.

Environmental law evolves from waste treatment theory that seeks to limit inputs. An alternative approach based on output standards would develop the waste as useful products and allow its movement out of the production area. The marketed "co-products" of the poultry operation would then be available for application or other use as needed.

The traditional uses of manure as fertilizer, feed, and energy point to the markets as a supplement, if not a substitution, for environmental regulation. As alternative waste management practices develop, growers who know the market can develop these traditional and new uses of manure, and deliver their "products" to the market biologically secure and environmentally safe. Recent law in Iowa and some other states, permits manure application laws to be relaxed if the growers' manure management plan can show that the excess has been sold and is being used responsibly. Such provisions are an indication of where management and regulations may be heading for the future.

At their best, regulations are a reminder that all of us must work to prevent the unintended consequences of our activities (i.e., nonpoint source pollution) from impairing the earth's resources or putting animal and public health at risk.

Definition of Farming Is Important

It is essential that growers participate in regional and state legislative, civic, and ad hoc environmental groups. It can remind those who make regulations that "feeding, breeding, and managing livestock, including to a variable extent the preparation of these products for human use," is part of the enterprise that Webster's dictionary identifies as farming.

Although commercial and industrial facilities face stricter restraints, such enterprises are usually larger and can often pass the cost of pollution prevention on to third-party customers or end users. This privilege is denied the farmer. Spotty regulations will play havoc in the market place. When compliance with regulations becomes costly in some localities, farmers are forced out of business because they cannot afford the extra expense that their competitors in less regulated areas do not incur.

Again, it is essential that growers participate as environmental regulations are being promulgated.

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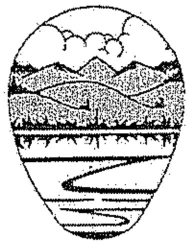

Air Quality and Its Management

The Clean Air Act of 1955 established specific National Ambient Air Quality Standards (NAAQS) for six compounds: carbon monoxide, ozone, particulate matter, sulfur dioxide, nitrogen oxides and hydrocarbons. Subsequent reauthorization and amendments (especially in 1970) provided for uniform air quality standards and control of emissions from existing facilities. That is, the regional U.S. Environmental Protection Agency offices or individual state regulatory agencies must monitor air quality, and design and implement plans to improve air quality to NAAQS-levels.

The Clean Air Act Amendment of 1990 (Pub. Law 101-549) also included several provisions of concern to producers of agricultural products. The most immediate of these concerns are the contribution of manure decomposition to ammonia emissions and the impact of manure handling on fugitive dust.

Particulate Matter

Particles of solid or liquid material suspended in air can cause eye and throat irritation and hamper visibility. To date, the air quality standard for particulate matter (PM) concerns compounds above 10 micrometers (µ) in aerodynamic diameter or PM_{10}. Regulation is pending, however, to set the standard at $PM_{2.5}$. This new rule, originally drafted to take effect in the summer of 1997, received widespread criticism and was not enacted. If or when it is enacted, ammonium nitrate — which is created by photochemical reaction between ammonia and nitric acid — will become a larger part of the total problem since the resulting particles are larger than 2.5µ.

Reducing the formation of particulate matter benefits air quality — and everyone benefits from cleaner air. So even without regulations, growers will likely do whatever they can to reduce ammonia emissions, that is, to reduce the moisture content of litter. Indeed, they have — sometimes for other reasons — already adopted management practices that will help achieve this goal, such as maintaining waterers in good condition, applying alum treatments to litter (i.e., bedding materials), and composting litter and mortalities.

Technological controls, such as installing equipment to scrub ammonia before the air is vented from buildings, may be more costly than the problem warrants. Some technological controls may be helpful; however, care should be taken to ensure that a technology devised to control a specific problem, such as the generation of methane gas, is not expected to remedy other problems. For example, covered lagoons will not do much to solve the fugitive dust problem.

It is important for growers to be aware of regulatory concerns and evaluate their management practices and prospective technologies holistically. The best practices are effective, economical, and do no harm to the environment.

Gaseous Emissions

Goals of the 1990 Clean Air Act include reducing emissions to the air that cause acid rain and protecting stratospheric ozone. Thus, ammonia (NH_3) volatilization from animal and other agricultural operations is subject to increased scrutiny.

A variety of gases are generated during the decomposition of poultry wastes. Under aerobic conditions, carbon dioxide (CO_2) is the principal gas produced; under anaerobic conditions, the primary gases are methane (CH_4) and

(CO_2). About 60 to 70 percent of the gas generated in an anaerobic lagoon or pit is methane and about 30 percent is (CO_2). Trace amounts of more than 75 other volatile compounds have been identified from degrading animal waste, including mercaptans (the odor generated by skunks and the smell introduced in natural gas are in the mercaptan family), aromatics, sulfides, various esters, carbonyls, and amines.

Methane, Carbon Dioxide, Ammonia, and Hydrogen Sulfide

The gases of most interest and concern in poultry waste management are methane, carbon dioxide, ammonia, and hydrogen sulfide. The following paragraphs summarize the most significant characteristics of these gases.

▼ **Methane.** Methane gas forms during the breakdown of animal wastes, if the decomposition process is anaerobic. Because methane is quite explosive, extreme care is required when attempting to generate and capture this gas for on-farm use.

Further, methane emissions from "rice and livestock production" and from "all forms of waste management . . . including storage, treatment, and disposal" are specifically mentioned as a concern in the 1990 Clean Air Act. Methane accounts for about 18 percent of the greenhouse gases that contribute to ozone depletion.

▼ **Carbon Dioxide.** Carbon dioxide can be an asphyxiant when it displaces normal air in a confined facility. Because CO_2 is heavier than air, it remains in a tank or other well-sealed structure, gradually displacing the lighter gases. With high-density housing, gas and particulate levels may increase, and control becomes more difficult.

Carbon dioxide can increase substantially inside the poultry house, depending on the number of birds producing it. Continued monitoring of temperature, air removal rate, and manure moisture content is required to maintain proper carbon dioxide concentrations.

▼ **Nitrous Oxide and Ammonia.** Ammonia is primarily an irritant and has been known to create health problems in animal confinement buildings. Irritation of the eyes and respiratory tract are common problems from prolonged exposure to this gas. It is also associated with soil acidification processes.

Ammonia concentration in broiler houses has increased in the past few years. The primary reason is that ventilation rates are reduced to conserve heat in the winter months. Research also shows that dust particles serve as an ammonia transport mechanism, so venting to the outside may lead to odors near the house and contribute to overly dry litter inside the house.

Ammonia concentration increases with increasing pH, temperature, and litter moisture content. It is desirable to maintain litter moisture in a production house below 30 percent for ammonia control. Studies indicate that ammonia increases bird susceptibility to Newcastle disease and decreases feed intake and egg production.

Nitrous oxide is produced during the breakdown of nitrogen fertilizers in soil, animal wastes, and nitrate-contaminated groundwater, although its major source is the burning of fossil fuels. Nitrous oxide accounts for about 6 percent of the greenhouse gases related to human activity.

▼ **Hydrogen Sulfide.** Hydrogen sulfide is deadly. Humans and farm animals have been killed by this gas after falling into or entering a storage tank or building in which a storage tank was being agitated. Although only small amounts of hydrogen sulfide are produced as compared to other major gases, this gas is heavier than air and becomes more concentrated over time.

Hydrogen sulfide has the distinct odor of rotten eggs. Hydrogen sulfide deadens the olfactory nerves (the sense of smell); therefore, even if the smell of rotten eggs appears to have disappeared, an area may still be contaminated with this highly poisonous gas. Forced-air ventilation or an exhaust system helps prevent gas poisoning. Otherwise, evacuate the area until the gas can be removed.

Methods used to capture and treat these gas emissions will have the additional advantage of reducing odor. They include the use of covered storage pits or lagoons, soil adsorption beds and filter fields, and applying litter with soil incorporation. Technological controls are possible, for example, installing packed bed scrubbers in the poultry house or composting area (or wherever the manure is processed. Newer methods include burning the manure to produce energy, which is discussed in AT/2.

Issues Not Directly Related to Air Quality

Nuisance issues, odor, flies, dust, and noise are generally regulated at the state or local level. They can be, but are not usually related to air quality standards, even though many citizen complaints and civil suits brought against livestock and poultry operators may reference such standards. These problems are more often related to improper or mismanaged burial pits, emissions from incinerators, and land applications of poultry waste. They are intensified by increasing urbanization, unanticipated adverse weather conditions, and specific, often seasonal, activities in the production cycle. Other fact sheets in this handbook deal with these potential problems.

Where to Go for Help

Information on achieving air quality standards and managing air quality problems related to poultry production facilities is available from the U.S. Department of Agriculture, U.S. Environmental Protection Agency, and the U.S. Department of Energy. Poultry associations and state water quality agencies can also help.

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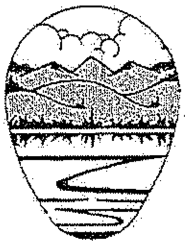

Controlling Odors — Multiple Purpose Management

Until the 1950s, many small poultry farms were in rural areas and produced fresh meat for city dwellers. The owners were backyard producers or family farmers (like your parents or grandparents) who raised chickens for their neighbors to bake or fry on Sunday. But the demand for chickens and eggs grew rapidly, and an assembly line model of continuous poultry production and processing raised the stakes.

Now breeder and hatchery operators, feed mills and chicken processing plants are "integrated" — owned by a single company — and the backyard farmer has retired. The farmer now contracts with the integrator to grow thousands of chickens under controlled conditions.

No sooner were these changes underway when a second trend developed: the migration of many nonfarming residents to settle in rural areas. The collision of these trends in the same watershed — that is, the concentrated animal feeding operations of today's farms and a burgeoning rural population — can lead to mutual misunderstandings. The community often feels that growers are making their lives unnecessarily pungent; and growers, many of whom have been there longer than the town, feel much maligned. Both sides have valid concerns.

A Confusion of Complaints

Concentrated animal feeding operations, as many livestock farms are called, have come under considerable scrutiny. One reason for the attention is concern for the animals' welfare. In fact, chickens and turkeys maintained in a well-managed poultry house can be as comfortable as those raised outdoors, and may be freer of disease. Veterinary doctors, university faculty, and growers are not likely to abandon their responsibility or respect for the animals, simply because they have moved them indoors.

Birds must be kept comfortable, and the wise grower does not forget the birds themselves, who by their behavior speak eloquently of their condition: they huddle when cold, pant and flap their wings when hot; and migrate to better areas if the problem is localized. The grower who cares about the birds will be a frequent visitor in the poultry house, coming and going at odd hours to monitor conditions (such growers will not, however, disturb the birds when it is very hot).

The condition of the litter is another indicator of bird comfort — as are temperature, humidity, air flow patterns and speed, ventilation cycles, and gaseous air contaminants. Many of these indoor indicators require engineering systems and mechanical monitoring. For example, growers may want to use a negative pressure system to bring outside air into the poultry house. The goal is to maintain the right static pressure and adjust the air inlets so that fresh air comes in high, shoots to the middle of the house, and stays high as it moves toward the center aisle. If it is properly mixed with the in-house air before it flows over the birds, it will help control odor and prevent cold air from flowing directly over the birds.

Human health and the environment are likewise of great concern to growers. Concentrated animal feeding operations can generate as much or more waste as an urban population, and agricultural runoff does not, like some other wastewater discharges, pass through a treatment plant. Environmentally sound animal waste management is, then, an urgent, but by no means impossible, priority. Growers who use best management practices to ensure proper waste management — from collection and storage to composting to land applications and value-added processing (e.g., to sell as a feed ingredient, fertilizer, or soil amendment) — will not be polluters and their facilities will not produce intolerable odors.

Tackling Odor Head on

The basic complaint associated with concentrated animal feeding operations is odor. Even though odor is generally more irritating than dangerous, it often evokes outrage from neighbors. Many growers, who may previously have ranked odor among the least pressing of their problems, are now encouraged to make it a priority. Odor, like flies, is ubiquitous and unlikely to be totally eliminated. But it can be controlled. Wherever strong odor is a problem, the most recent tendency is to treat it as a pollutant and quite possibly to find the grower in noncompliance with regulations.

Odor may be endemic to feed lots, houses, litter storage facilities, lagoons, and land applications, but its strength, or nuisance quotient, depends on site-specific conditions and management procedures, such as location, sanitation practices, season, climate, time of day, and wind direction and speed. Having an appropriate poultry waste management system is essential, and the most useful odor prevention measures are therefore found throughout the factsheets included in this handbook.

Litter is a naturally occurring biodegradable waste. Ammonia and other nitrogen compounds and some gases generated in the decomposition process are the primary sources of the offending odor. If the decomposition process occurs in the presence of sufficient oxygen, few odors are produced. However, anaerobic decomposition produces many odorous and some dangerous gases. At least 75 odorous compounds can be produced in the decomposition process, including, for example, volatile organic acids, aldehydes, ketones, amines, sulfides, thiols, indoles, and phenols. For this reason, it is good management to store litter in a covered, dry stack facility, and to follow spreading by a method of incorporating the litter into the soil. Properly applied litter increases plant growth and contributes to natural nutrient recycling (see PWQ/3) with no environmental damage and little odor.

How Odor Affects Us

The physiological sense of smell, which is perhaps never as keen as sight or hearing, can vary as much as a thousandfold from person to person, and can be affected by age. Thus, for example, children under age 5 seem to like all smells; children over 5 do not; though one's sense of smell decreases with age. At age 20, people have 80 percent of their physiological sense of smell; at age 80, about 28 percent. Other things that make a difference in one's sense of smell are smoking habits, allergies, and head colds.

Behavioral responses to odor are equally diverse. Some individuals can be genuinely unaware of odors that are a nuisance to others. In addition, ammonia and hydrogen sulfide should be monitored since both suppress the sense of smell. Odor fatigue makes it impossible to smell certain odors, while simple adaptation also accustoms one to certain smells. However, studies to determine the effects of odor on people living near confinement facilities or on farms where litter is managed show that olfactory receptors renew themselves every 30 days; that frequency and duration are weather related, and that odors can definitely affect people's moods and nervous systems and cause depression and nausea.

Within these limits, it is possible for individuals to sense the presence or absence of an odor — even when they cannot quantify its five basic properties: intensity, degree of offensiveness, character, frequency, and duration. The more accustomed we are to odors; the higher the threshold must be before we detect them.

Updating Standard Practices

As good management is the key to controlling odor, so keeping up with new developments is important for all managers. New developments are part technological breakthroughs and part trial and error; and many of them have been discovered by farmers solving real life problems. Consider, for example, the growers' concern for the birds' welfare and for controlling odor. Choices that the grower makes before and during production, for example, about which bedding material to use and what diet to feed the birds, may contain some of the trade-offs the grower is looking for.

Some growers report that they have gotten good results — better flock health and less odor — by using recycled paper, leaves or other green manure as an alternative to straw bedding material. Others have found that the addition of phytase to the birds' diets helps reduce both ammonia volatilization and odor since the more efficiently the chickens use phosphorus, the less they have to excrete. And, as the long-term effect of this choice may well be that less phosphorus is available for land applications, the grower who uses phytase obtains a three-way trade: less nuisance odor, less environmental damage, and better bird performance.

Other management choices for laying operations that reduce odor, contribute to the flock's performance, and protect the environment include flushing the houses with clean water, keeping the waterers in good condition, and drying the manure. The use of separation and setback distances, riparian and other buffers and windbreaks, and restrictions on land applications on frozen ground or when rain is predicted — also help control odor and contribute to the growers' bottom line and reputation for good citizenship.

Above all, growers should not try to cover up odors by putting their heads in the sand, blaming other farm sites, or thinking of their neighbors as city slickers unused to earthy smells. Nor should they rely on the other kind of cover up: the one that uses chemicals or other additives to mask the odor. Most of the claims for commercial products are still unconfirmed.

Here, then, is the fundamental principle: Know the causes and cures. Unless growers know how odors are generated; that is, the factors producing them, they cannot know what control practices can be used to counter their effects. Once we have a grip on the causes, four basic strategies are available.

- Of most importance, prevent odor from developing in the first place. It bears repeating: locate the poultry facility away from other farm buildings and residences, handle litter in a dry state as much as possible, and remove all mortalities and broken eggs, and spilled feed immediately.
- Alter the unpleasant smells by chemical or microbiological treatment. That is, use a collection and storage treatment that can include drying the litter, composting, anaerobic digestion, and disinfection.
- Contain the odors; prevent their escape into the atmosphere by regular washdowns for layer operations to minimize dust and feathers, and by using well-maintained waterers, good ventilation equipment, and bedding materials that repel moisture.
- Disperse and dilute odors once they do escape into the atmosphere. For example, consider the wind direction and other weather conditions before applying litter, and plant or take advantage of natural windbreaks; riparian forests or buffers, and injection or other soil incorporation methods to reduce the odor associated with land applications. In addition, exhaust fans can be pointed away from other buildings or down to the ground so that stale malodorous air is deflected into the ground near the housing facility.

Methods used to capture and treat gas emissions are needed to protect air quality and to reduce odor. They include the use of covered storage pits or lagoons, soil adsorption beds and filter fields, and appropriately planned land applications. Odors associated with toxic gases are protective; noxious smells, on the other hand are a nuisance and leave us feeling unprotected. The former trigger safety precautions; the latter, evoke the strongest possible repugnance, and may increase rather than decrease now that scientists are coming up with ways to measure odor.

Adjudicating claims between noses is a risky business. However, growers are not alone in this effort. Assessments of on-farm conditions can be a helpful management tool and a powerful support in contested cases. Local, state, and federal natural resource agencies, the USDA Natural Resources Conservation Service, and the Cooperative Extension Service can help growers assess their management systems, prepare appropriate resource management plans, and learn how to maintain simple, but sufficient records to show that their operations are effectively managed to prevent both odor and environmental contamination.

Conclusion

The best way to deal with odor problems is at the beginning of the production cycle and through a commonsensical approach. The problems have mundane origins; they may be related to improper or mismanaged burial pits, emissions from incinerators, or land applications and intensified by increasing urbanization, unanticipated adverse weather conditions, and specific, often seasonal, activities in the production cycle. Other fact sheets in this handbook deal with these practices.

Simultaneously, however, the chemical basis of odors, variations in detection thresholds, and differences in the degree of offensiveness make it imperative to handle the problem of odor via litter management *and* public relations. Attitudes must always be taken into account since odor is better accepted by individuals who see the grower as a friend, community member, and neighbor. Protecting natural resources and improving relationships may be the long-term solution to abiding in the same watershed.

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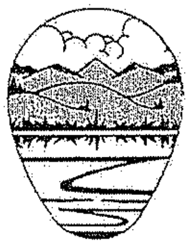

Preventing Fires in Manure/Litter Storage Structures

Hundreds of poultry manure/litter storage structures have been built as a component of a total waste management program on the poultry farmstead. Storage facilities help prevent the possibility of water pollution and provide flexibility in the timing of land applications. They also protect this resource from the weather and wildlife so that it can be used as a fertilizer or cattle feed.

Manure piles will generate heat, however, and care should be taken to prevent fires in the storage facility. Spontaneous combustion in a litter stack is possible, probably as a result of the buildup of combustible methane from the storage of wet and dry litter. Fires may also occur if the manure is stacked too close to wooden walls that may ignite when the temperature in the litter reaches the wood's flash point. The exact causes of litter storage fires are difficult to know, but good management principles will help protect the litter and reduce the risk of fire.

Methane Production

Anaerobic bacteria generate about 50 to 65 percent methane, about 30 percent carbon dioxide, and a smaller percentage of other gases. If the moisture content of stored litter is more than 40 percent in a stack with little or no oxygen, then conditions are right for anaerobic bacteria to grow and methane to result. Unvented landfills have the same problem. Methane's specific gravity is less than air, however. If the stack has adequate pore spaces (or the landfill has ventilation pipes), the methane will escape into the atmosphere.

High moisture levels in stored litter help create the potential for fires, as does layering the manure (putting new litter on top of old litter). Compacting the litter will trap heat in the pile, and failure to provide an adequate ratio of surface area to volume can also create problems.

Tips for Fire Prevention

The following guidelines will help prevent fires in storage facilities:

- Keep the litter dry and do not stack it too near the open end of the building where it is more likely to get wet (methane is flammable in air).
- Do not compact moist cake or mix it with dry litter; and do not stack cake or dry litter higher than 5 feet or store it against the wood.
- Do not compact the dry litter, since compacting creates anaerobic conditions and prevents the natural venting of methane.
- Do not cover moist litter but allow the litter to vent naturally.
- Monitor the resources in your storage facility regularly, and remove any materials that have temperatures greater than 180 °F. If the temperatures exceed 190 °F, notify the fire department and prepare to move the material. Emptying the storage area will bring the litter out into the air, so precautions must be taken against a fire occurring at this time.

OTHER ENVIRONMENTAL ISSUES

It is a good idea not to store expensive equipment in the litter storage facility.

If you are storing dry litter for later use as a cattle feed, cover it with polyethylene. This technique will suppress the temperature buildup and reduce the production of bound nitrogen, a form of protein that cattle are unable to digest.

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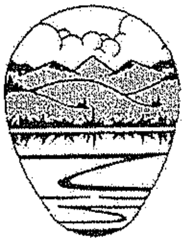

Controlling Struvite Buildups

Magnesium ammonium phosphate, sometimes called struvite, is a grayish-white crystalline salt that builds up on the internal pump and piping surfaces used for lagoon liquid recycling. It usually appears on metallic surfaces but can also form on plastics. Steel, cast iron, bronze, and brass are equally susceptible.

Struvite usually builds up on the internal pump components first, then moves outward to the discharge pipes. It often occurs at pipe joints, elbows, valves, or imperfections because microscopic grit and solids tend to lodge at these points, providing a base for the salt to grow. Predicting struvite is difficult because its cause is not well known. Design, maintenance, and management techniques have been researched that can reduce the buildup to acceptable levels.

Pumping and Piping System

Use only high-quality, low-pressure, self-priming centrifugal or submersible pumps. They should not be oversized in relation to the piping network, and should perhaps be on a timer. The suction pipe should also be large enough to prevent pump cavitation. Normally the suction pipe diameter should be one size larger than the discharge pipe. Locate the pump close to the high-water level to minimize suction lift. Replace fine mesh suction intake strainers with wire screens or baskets of 1-inch mesh or larger. The diameter should be at least five times the diameter of the suction pipe. Struvite will also build up on the screens.

Use nonmetallic pipes and fittings. Pipes should be large enough to maintain flow velocities between 3 to 5 feet per second; the minimum pipe diameter at any point except at the immediate discharge point should be 1.5 inches. Sharp pipe bends (elbows and tees) should be avoided. Instead, use flexible plastic pipe and long sweep elbows for the direction changes. The system (pumps and piping) should have sufficient capacity to work only one-half to two-thirds of the time, and piping systems not in continuous use should be drained between pumping events.

Electrostatic Charges

Stray voltage is also believed to contribute to struvite. Direct grounding of the pump housing can discharge any static charges. A metal rod should be placed 10 to 12 feet into the moist soil near the lagoon's edge, and cable connections at the ground rod and pump should be checked periodically for corrosion.

Lagoon Management

Lagoons should be properly sized. New ones should be charged at least half full of water before startup, and the liquid level should be brought up to design levels as soon as possible. Rainfall during normal years dilutes lagoon liquid while extended periods of hot, dry weather increase nutrient and salt levels and the rate of salt buildup in recycling systems. Flushing with fresh water or irrigating with a portion of the lagoon contents may help.

Acid Cleaning

Salts can be dissolved with dilute acid treatments. Several doses followed by flushing the spent acid solutions will be needed to treat heavy buildups. A more thorough and more costly method is to install an acid recirculation loop. Use a 150-gallon acid-resistant tank as the reservoir. You will need enough solution to fill the pipe length and some in reserve to keep the recirculation pump primed. Use the accompanying table to determine how much acid you will need.

Table 1.—Amount of solution needed for acid cleaning using an acid recirculation loop.

DIAMETER OF PIPE (INCHES)	SOLUTION NEEDED PER FT OF LENGTH (GALLONS)
1.0	0.06
1.5	0.13
2.0	0.20
2.5	0.29
3.0	0.43
4.0	0.70
6.0	1.53

To reduce the size of the tank, isolate sections of the line with valves and circulate the acid through only one section. The flush pump suction is switched from the lagoon and connected to the bottom of the acid tank with a quick-connect coupling. A 1-inch line returns acid from the end of each treated pipe section to the tank.

Hydrochloric acid can be purchased at most chemical supply houses or paint stores. Dilute the acid with water on a 1 to 9 ratio — 1 gallon acid to 9 gallons of water. Use caution. Mixing acids with water is a hazardous operation. Partially fill the tank with water, then add the acid slowly to the water. Eye protection is essential, and heat will be generated. To treat heavy struvite buildups, recirculate the mixture overnight and count on using the mixture only once. Spent acid may be dumped into the lagoon. Acids currently cost about $14 for a 15-gallon drum or about $33 for a 50-gallon drum. Deposits on the drums are $25 and $50, respectively.

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Protection Against Pests, Predators, and Darkling Beetles

Pests are vectors because they may be a point of entry for disease or other nuisances in the poultry house. They are also an aspect of waste management that should not be overlooked. Vectors can be either living or nonliving carriers of disease. Especially troublesome on the poultry farm are house flies, rats, and darkling beetles. Wildlife, especially feral dogs and coyotes, must also be controlled. Having proper waste management facilities and maintenance procedures on the farm will contribute to productivity, nutrient management, and environmental safety. A cost-effective and safe pest control system is essential.

Uncontrolled pests cause irritation to birds and workers, carry poultry disease pathogens, increase mortality, lower carcass grades and production, damage building materials, and interfere with feed conversion. In addition, and if they did nothing else, poultry pests must be carefully controlled because they can migrate from litter to nearby residences, where they may become a serious nuisance among the neighbors.

Rats and Mice

Voles, field mice, and cotton rats are not usually the source of problems for poultry growers. Norway rats and roof rats, however, are two non-native species of rats that can be troublesome — and they proliferate rapidly. A pair of rats will produce six to 12 young in 21 days — and each of these becomes sexually mature in three months. A single pair of rats, if they find food, water, and shelter, can produce a colony of 640 rats in a year.

Poultry houses provide everything the rats need: food, water, and shelter. Norway or wharf rats usually nest under buildings and concrete slabs and in garbage dumps. They are great burrowers and may have an extensive system of burrows under the poultry house, with several escape routes. They eat anything but prefer nuts, grains, meats, and some fruits. They can easily find meats and grains in the poultry house.

Roof or black rats are more aerial than Norway rats. They enter buildings from the roof or utility lines. They usually live in trees, so access to the poultry house is easy: up the walls, across vines, along pipes. Exterior walls should be hard, flat surfaces, and all entrance holes should be plugged up. Rats can make themselves "paper thin" to come in under doors and through holes as small as one-half inch in diameter.

The best rat control program is proper resource management, maintenance, and sanitation; but the food supply in the poultry house makes rat occupation probable. Some chemical controls or rodenticides may, and probably should be, added to your control program. To administer rat poison effectively, first know how many rats you are dealing with; then, establish bait stations near the walls in areas of rodent activity.

To determine how many rats are in the poultry house, observe the area at night as well as in the daylight. Rats are nocturnal; if you see no rats in the day or at night, there probably are not many around. If you see old droppings or gnawed areas, no rats during the day, and only a few at night, rats are probably pre-